Original Research Article

Floristic composition in chronosequence in Atlantic Rainforest fragments

ABSTRACT

Secondary forests play an important role in tropical landscapes and have important ecological functions such as the ability to accumulate biomass. Although the literature points to the convergence between primary and secondary forests, however there are few studies in Atlantic Rainforest in a chronosequence to show it. This study aimed to characterize the changes of floristic composition in a chronosequence (5, 16, 24, 30 years of regeneration and mature forest) in the Atlantic Rainforest. He sought to answer the following questions: Young forests tend to converge resembling floristically with mature forest? In case of this floristic convergence from what age these young forests present rate of growth closer forms of mature forest? The fact that about 35% of the tree species are present in young and mature forests suggests that the floristic composition of young forests tends to resemble the mature forest. The results suggest that from 16 young forests tended to converge with the mature forest in terms of the proportion of growth forms.

Keywords: Floristic convergence, Young forests, Growth forms, Secondary rainforest.

1. INTRODUCTION

Secondary forests play an important role in tropical landscapes. These ecosystems are sources of timber and non-timber products and generally perform important ecological functions, such as the ability to accumulate biomass and nutrients at high rates, maintain biogeochemical cycles and water conservation at levels comparable to primary forests [1,2]. Current research on succession in secondary forests in the tropical regions occurs especially in studies in chronosequences [3].

Regarding succession [4] proposed that it is a highly ordered and predictable process, emphasizing the sequential substitution of herbaceous species by shrubs and finally arboreal species. Differently, [5] suggested that the sequence does not have this fixed and regular sequence, being influenced by the composition of the community, which is determined by stochastic factors.

In relation to floristic composition throughout the succession, [6] described two alternative scenarios. The floristic rotation, with a broadly clementsian view, in which each group of species colonizes the place at certain stage of development, thus making conditions unsuitable for itself and more appropriate for colonization of the next group, at the final stage of succession convergence with the region's mature vegetation. Other scenario is the hypothesis of initial floristic composition, which proposes that after the abandonment of a site, development unfolds from the initial flora; [6] concluded that the secondary succession

36 is determined more by the initial floristic composition of an area than by the floristic rotation
37 proposed by [4].

38 At present, it is known that natural landscapes, in general, have a historical complex of land
39 use disturbances [7]. These authors argued that succession represents a series of
40 unpredictable events that results from interactions between individuals and the abiotic
41 environment, involving different patterns (convergence or divergence), mechanisms and
42 causes that lead to complex paths that will determine the processes of recovery of the local
43 vegetation. The trajectory followed by the sequence depends on the initial conditions and
44 stochastic events. The results of chronosequences found in tropical forests by several
45 authors [2,8] have reported floristic convergence with mature vegetation.

46 Although the literature cites some papers that point to convergence, it is known that there
47 are studies reporting the floristic divergence along the chronosequence [9,10]. The authors
48 argued that this may be due to less similarity of habitats and/or landscape effects [11]. On
49 the landscape effect, [12] found that in landscapes with less than 10-30% of vegetation
50 covering, there are negative effects on the persistence of the species due to the combined
51 effect of landscape area and geometry, which may lead to convergent or divergent
52 trajectories, according to the degree of vegetative cover.

53 From the perspective of the current literature, there is still a great deal of research to be
54 done. The present research aims to characterize the changes in floristic composition in a
55 chronosequence (5, 16, 24, 30 years of regeneration and mature forest). Thus, we sought to
56 answer the following questions: From what age do young forests present a proportion of
57 growth forms closer to the mature forest? Do young forests tend to diverge or converge
58 floristically with mature forest?
59
60 **2. MATERIAL AND METHODS**
61
62 **2.1. Local study and selection of areas**

63 The fragments of mature and young forest studied are located at the São José Plant (USJ)
64 (07° 54' 17" - 07° 54' 41"S, 34° 54' 17 "- 35° 05' 07"), located in the Zona da Mata Norte de
65 Pernambuco, in the domain of the Dense Ombrophylous Forest [13]. The property occupies
66 270 km², where it has forest remnants that cover 24% of the landscape, being the average
67 size of the fragments of 61 ha, occupying the less useful areas for planting [14].

68 The local climate is As' (hot and humid), with an annual average temperature of 24.9 °C,
69 average rainfall of 1687 mm (Laboratory of Meteorology of Pernambuco - LAMEPE/ITEP).

70 Young forests with 5, 16, 24 and 30 years of regeneration were selected from aerial
71 photographs of the 1960s, 1970s, 1980s, 2005 satellite images and interviews with former
72 residents. As a comparison, an area of mature forest (over 60 years old) studied by [15] was
73 selected. It is important to point out that mature forest is the one in which we can guarantee,
74 based on cartographic material and interviews, that there was no intervention in the last 60
75 years.

76 **2.2. Data collect**

77 Thirty plots of 10 × 10 m were sampled in each forest of the chronosequence, as well as the
78 floristic survey near the plots. The collection was carried out by the walking method [16],
79 according to the usual collection techniques for plants [17]. The studied habits were: 1)
80 arboreal; 2) shrub; 3) grass; 4) bindweed (woody) and 5) epiphyte.

2.3. Analysis and processing of data

The species sampled were identified with the help of experts and comparisons with collections deposited at the Herbarium Sergio Tavares (HST) and Dárdano de Andrade Lima (IPA). The exsiccates were placed in the Herbarium Professor Vasconcelos Sobrinho (PEUFR). The classification of angiosperm families followed the recommendations of [18].

To test the possible convergence or divergence of habits between the different dropout ages and the proportion between the different habits during the chronosequence, one-way ANOVA was applied, followed by the post-hoc Tukey test through the PAST 2.01 software [19].

In order to verify if there is floristic convergence between the young forests and the mature forest the degree of floristic similarity between the tree species in the chronosequence was evaluated. To do this, we performed: 1) a clustering analysis using the Jaccard similarity index and the mean linkage method per group (UPGMA) [20]; 2) Principal component analysis (PCA), Multidimensional linear analysis technique [21], and 3) non-metric multidimensional scaling (NMDS) [22]. Based on the tree species present in the five ages, a presence/absence matrix was elaborated to analyze if there would be indicator species for each age, using TWINSPAN (Two Way Indicator Species Analysis) analysis [23] using PC-ORD version 4.0 [24]. The option to analyze only trees occurred because it is the best registered habit in the five areas.

3. RESULTS AND DISCUSSION

In the five fragments sampled, 198 taxa were recorded, distributed by 131 genera and 59 families (Table 1). In the area of 5 years, 66 species and 42 families occurred, being Myrtaceae and Melastomataceae the most representative. In the forest of 16 years of abandonment, we found 75 species and 44 families, with greater representation of Fabaceae, especially the subfamilies Papilionoideae and Mimosoideae. In the area of 24 years, 88 species and 51 families occurred, Myrtaceae being the one with the greatest number of species. In the 30 years, with 75 species and 41 families, with highlight to Myrtaceae and Fabaceae (Mimosoideae) families, due to the greater species richness. In the mature forest, there were 95 species and 52 families, with Myrtaceae, Sapindaceae and Rubiaceae with the largest number of species (Table 1).

The trends observed during the chronosequence in the fragments at the São José Plant reveal that in the youngest forest (5 years) there were several herbs with a short life cycle and an increase in the number of tree species and decrease of the herbs in the more advanced stages (16, 24, 30 and mature), what was pattern observed in other chronosequence studies [25,26,27].

Tree habit showed the highest number of families (43) and species (124), from these 124 species, 51 occurred in the young forests and 72 in the mature forest, and the two groups shared 43 species. The families that presented the greatest wealth of trees were Myrtaceae and Fabaceae (Mimosoideae), with 15 and 10 species, respectively. There was an increase in the number of species in the families Sapindaceae, Annonaceae, Myrtaceae and Fabaceae throughout the chronosequence; from these 124 tree species recorded in young forests and mature forest, 15 species (12.9%) were common at all ages (Table 1).

The shrub habitat presented 13 families and 39 species. In the herbs group, 12 families and 19 species were recorded (Table 1). Among the bindweed, nine families and 16 species

127 were recorded (Table 1). The epiphyte of the hemiparasite type *Psittacanthus dichrous*
128 (Loranthaceae) was found only in the young forest of 5 years.

129 It can be noticed an advance to a more typical pattern of mature forests from 16 years after
130 the abandonment, due to the increase of the trees and decrease of the herbaceous ones,
131 showing the directional substitution of forms of growth.

132 The small trees that occurred in all the young forests are typical species of edges and
133 clearings of forests [28,29], being present in the young forests in sunny areas [30].
134
135 **Table 1.   Species recorded in four fragments of young forests (5, 16, 24 and 30) and**
136 **a mature forest. ARO - Arboreal, TRE - Bindweed, ARB - Bush, ERV - Herb, EPI -**
137 **Epiphyte. Young forests (FJ5 = 5 years = 16 years FJ16, FJ24 = 24, FJ30 = 30 years)**
138 **and mature forest (FM). * - arborescent plant with similar size to tree. Through the**
139 **analysis of indicator species TWINSPAN: ♦ mature forest; • young forests.**

Specie	Habit	FJ5	FJ16	FS24	FS30	FM
Anacardiaceae						
Anacardium occidentale L.	ARO				X	
Mangifera indica L.	ARO		X			
Tapirira guianensis Aubl.	ARO	X	X	X	X	X
Thyrsodium spruceanum Benth.	ARO		X	X	X	X
Annonaceae						
Anaxagorea dolichocarpa Sprague & Sandwith	ARO		X			
Annona salzmannii A.DC.	ARO					X
Guatteria cf. australis A. St.-Hil.	ARO					X
Guatteria pogonopus Mart.	ARO					X
Guatteria schomburgkiana Mart. ♦	ARO	X	X			X
Xylopia frutescens Aubl.•	ARO	X	X	X	X	
Apocynaceae						
Condylocarpon sp.	TRE		X			
Himathanthus phagedaenicus (Mart.) Woodson	ARO	X	X	X	X	X
Rauvolfia grandiflora Mart. ex A.DC.	ARB		X	X		
Tabernaemontana flavicans Willd. ex Roem. & Schult.	ARO					X
Araliaceae						
*Schefflera morototoni (*Aubl.*)* Maguire, Steyerm. & Frodin	ARO	X	X	X	X	X
Arecaceae						
Acrocomia sclerocarpa Mart.*•	ARO	X	X	X	X	
Bactris ferruginea Burret*	ARO					X
Desmoncus sp.	TRE					X
Elaeais guineensis Jaquim *	ARO	X		X	X	

Asteraceae						
Conocliniopsis prassifolia (DC.) R.M. King & H.Rob.	ARB					X
Conyzas umatrensis (Retz.) E. Walker.	ARB	X				
Pterocaulonalo pecuroides (Lam.) DC.	ERV	X				
Sphagnetico latrilobata (L.) Pruski	ERV	X				
Tilesiabaccata (L.) Pruski	ARB		X	X		
Boraginaceae	ARB		X			
Tournefortia candidula (Miers) I.M. Johnst.						
Burseraceae						
Protium heptaphyllum (Aubl.) Marchand	ARO	X	X	X	X	X
Cecropiaceae						
Cecropia pachystachya Trécul.	ARO	X	X	X	X	X
Celastraceae						
Maytenus distichophyla Mart. Ex Reissek ♦	ARO		X	X		X
Maytenus obtusifolia Mart.	ARO	X				X
Chrysobalanaceae						
Hirtella racemosa Lam.	ARB	X		X	X	X
Licania tomentosa (Benth.) Fritsch	ARO	X				
Clusiaceae						
Clusia nemorosa G.Mey	ARO	X				X
Rheedia gardneriana Tlanch. & Triana	ARO					X
Symphonia globulifera L. f.	ARO		X			
*Vismia guianensis (*Aubl.) Pers.•	ARO	X	X	X	X	
Cochlospermaceae						
Cochlospermum vitifolium (Willd.) Spreng.	ARO		X	X		
Combretaceae						
Buchenavia tetraphylla (Aubl.) R.A. Howard	ARO				X	X
Convolvulaceae						
Jacquemontia glaucescens Choisy.	TRE	X				
Dilleniaceae						
Davilla aspera (Aubl.) Benoist	TRE		X			
Davilla sp.	TRE					X
Tetracera breyniana Schltdl.	TRE		X	X		
Tetracera sp*.*	TRE	X				
Ehretiaceae						
Cordia multispicata Cham*.*	ARB				X	
Cordia nodosa Lam.	ARB				X	X
Cordia sellowiana Cham*.*	ARO				X	

Species	Habit					
Cordia superba Cham.	ARO					X
Erythroxylaceae						
Erythroxylum citrifolium A. St.-Hil.	ARB		X	X	X	X
Erythroxylum mucronatum Sw.	ARB			X		
Euphorbiaceae						
Croton floribundus Spreng.	ARO			X		
Croton sp.	ARO				X	
Euphorbia hyssopifolia L.	ERV	X				
Microstachys corniculata (Vahl) Griseb.	ERV	X				
Fabaceae – Caesalpinoideae						
Apuleia leiocarpa (Vogel) J.F. Macbr.	ARO	X	X		X	
Bauhinia sp.	ARO				X	
Dialium guianense (Aubl.) Sandwith ♦	ARO					X
Senna georgica H.S. Irwin & Barneby	ARB		X		X	
Senna quinquangulata (L.C. Rich.) H.S.Irwin & Barneby	ERV		X			
Swartzia pickelii Killip ex Ducke	ARO	X	X		X	
Fabaceae – Mimosoideae						
Abarema cochliacarpos(Gomez) Barneby & Grimes	ARO	X				X
Albizia polycephala (Benth.) Killip.•	ARO		X	X	X	
Albizia saman (Jacq.) F. Muell.	ARO			X	X	
Inga cayennensis Sagotex Benth.	ARO	X	X			X
Inga flagelliformes (Vell.) Mart.	ARO		X			
Inga ingoides (Rich.) Willd.	ARO			X	X	
Inga thibaudiana DC.	ARO		X	X	X	X
Inga sp.	ARO					X
Plathymenia foliolosa Benth.	ARO		X		X	X
*Stryphnodendron pulcherrimum (*Willd.) Hochr.	ARO				X	
Fabaceae – Papilionoideae						
Andira fraxinifolia Benth.	ARO		X			
Andira nítida Mart. Ex Benth.	ARO					X
Bowdichia virgilioides Kunth	ARO	X	X	X	X	X
Desmodium axillare (Sw.) DC.	ERV		X			
Desmodium barbatum (L.) Benth.	ERV	X				
Dioclea virgata (L.C.Rich.) Amshoff	TRE	X				
Machaerium hirtum (Vell.) Stellfeld	ARO			X	X	X
Machaerium salzmannii Benth.	ARO		X			
Stylosanthes scabra J. Vogel	ARB	X				

Heliconiaceae						
Heliconia psittacorum L.	ERV				X	
Heliconia sp.	ERV			X		
Hernandiaceae						
Sparattanthelium botocudorum Mart.	ARB			X	X	X
Humiriaceae						
Sacoglottis mattogrossensis Benth.	ARO					X
Lamiaceae						
Marsypianthes chamaedrys (Vahl) Kuntze	ERV	X				
Lauraceae						
Ocotea gardneri (Meissn.) Mez	ARO					X
Ocotea glomerata (Nees) Mez	ARO		X	X	X	
Ocotea indecora (Schott) Mez	ARO					X
Ocotea limae Vattimo	ARO					X
Lecythidaceae						
Eschweilera ovata (Cambess.) Miers.	ARO	X	X	X	X	X
Gustavia augusta L.	ARO			X	X	
Lecythis pisonis (Cambess.) Miers. ♦	ARO					X
Loganiaceae						
Strychnos bahiensis Krukoff & Barneby	ARB		X			
<u>*Strychnos*sp.</u>	ARB				X	X
Loranthaceae						
*Psittacanthus dichrous (*Mart.) Mart.	EPI	X				
Malpighiaceae						
Byrsonima sericea A.DC.	ARO	X	X	X	X	X
Stigmaphyllon blanchetii C.E. Anderson	ERV				X	
Malvaceae						
Apeiba tibourbou Aubl.•	ARO			X	X	X
Guazuma ulmifolia Pers.	ARO			X		
Luehea paniculata Mart.	ARO			X		X
Sida rhombifolia L.	ERV	X				
Melastomataceae						
Clidemia capitellata (Bonpl.) D. Don*.*	ARB	X	X	X	X	
Clidemia hirta Cong.	ARB	X				
Henriettea succosa (Aubl.) DC.	ARO	X	X			X
Miconia albicans (Benth.) Triana	ARB	X	X	X	X	X
Miconia ciliata (Rich.) DC.	ARB	X	X	X		X
Miconia minultiflora (Bonpl.) DC.	ARO	X	X	X	X	
Miconia prasina (Sw.) DC.	ARO			X	X	

Species	Habit					
Miconia sp.	ARB			X	X	
Meliaceae						
Guarea guidonia (L.) Sleumer	ARO			X		
Trichilia lepidota Mart.	ARO					X
Menispermaceae						
Cissampelos sp.	ERV					X
Monimiaceae						
Siparuna guianensis Aubl.	ARO		X	X	X	
Moraceae						
Artocarpus heterophyllus Lam. •	ARO		X	X	X	
Brosimum guianense (Aubl.) Huber	ARO	X	X	X	X	X
Sorocea hilarii Gaudich.	ARO		X	X	X	X
Myristicaceae						
Virola gardneri (A. DC.) Warb.	ARO		X			
Myrsinaceae						
Rapanea guianensis Aubl.	ARO		X	X	X	X
Myrtaceae						
Calyptranthes brasiliensis Spreng.	ARO			X		X
*Campomanesia dichotoma (*O.Berg) Mattos	ARO	X	X	X	X	X
Eugenia florida DC.	ARO			X		
Eugenia punicifolia (Kunth) DC.	ARO	X			X	X
Eugenia umbrosa O. Berg	ARO					X
Eugenia sp.	ARO	X		X		X
Myrcia fallax (Rich.) DC.	ARO		X			X
Myrcia *guianensis (*Aubl.) DC.	ARO	X	X	X	X	X
Myrcia racemosa Barb. Rodr.	ARO	X	X	X	X	X
Myrcia sylvatica (G. Mey.) DC.	ARO	X	X	X		X
*Myrcia tomentosa (*Aubl.) DC.	ARO		X	X	X	
Myrcia sp.	ARO	X			X	
Myrciaria ferrugínea O.Berg	ARO					X
Psidium guajava L.	ARO			X		
Psidium guineense Sw.	ARO	X	X	X	X	
Nyctaginaceae						
Guapira laxa (Netto) Furlan	ARO		X			
Guapira nítida (Schmidt) Lundell	ARO				X	X
Guapira opposita (Vell.) Reitz	ARO					X
Neea sp.	ARO					X
Ochnaceae						
*Ouratea castaneifolia (*DC.) Engl.	ARO					X

Olacaceae

Schoepfia brasiliensis A. DC.	ARB		X			X
Ximenia americana L.	ARO	X				

Passifloraceae

Turnera ulmifolia L.	ERV	X				

Peraceae

Pera ferruginea (Schott) Müll. Arg.	ARO	X	X	X	X	X
Pogonophora schomburgkiana Miersex Benth.♦	ARO		X			X

Piperaceae

Piper arboreum Aublet	ARB			X		X
Piper marginatum Jacq.	ARB			X		

Poaceae

Urochloafusca (Sw.) B.F. Hansen & Wunderlin	ERV			X		

Polygonaceae

Coccoloba mollis Casar.	ARO			X	X	X

Ranunculaceae

Clematis dioica L.	TRE			X		X

Rhamnaceae

Colubrina glandulosa Perkins.	ARO			X		
Gouania sp*.*	TRE					X

Rubiacae

Alseis pickelii Pilg. & Schmale	ARO					X
Borreria verticillata (L.) G. Mey	ERV	X				
Diodia apiculata (Roem. &Schult.) K. Schum.	ERV			X		
Diodia sp*.*	ERV					X
Genipa americana L.	ARO	X				
Palicourea crocea (Sw.) Roem. & Schult.	ARB		X		X	X
Posoqueria longiflora Aubl.	ARO					X
Posoqueria sp*.*	ARO	X				
Psychotria barbiflora DC.	ARB		X	X	X	X
Psychotria bracteocardia (DC.) Müll. Arg.	ARB		X		X	
Psychotria capitata Ruiz & Pav.	ARB			X		
Psychotria carthagenensis Jacq.	ARO			X		X
Psychotria cf. deflexa DC.	ARB					X
Psychotria hoffmannseggiana (Willd. ex Roem. & Schult.)	ARB		X			
Psychotria sp*.*	ARB				X	
Richardia grandiflora (Cham. &Schltdl.)	ERV	X				

Steud

Sabicea grisea Cham. & Schltdl.	TRE	X		X	X	
Salzmannia nítida DC.	ARB					X
Rubiacae	ARB		X			
Rutaceae						
Ertela trifolia (L.) Kuntze	ERV	X				
Zanthoxylum rhoifolium Lam.	ARO			X		
Salicaceae						
Banara brasiliensis (Schott) Benth.	ARO			X		
Banara guianensis Aubl.	ARO			X		
Casearia javitensis Humb., Bonpl. & Kunth	ARO			X	X	X
Casearia sylvestris Sw.	ARO	X		X	X	X
Casearia sp.	ARO				X	
Sapindaceae						
Allophylus edulis (A.St.-Hil., Cambess. & A. Juss.) Radlk.	ARO	X	X	X	X	X
Cupania oblongifolia Mart.	ARO			X	X	X
Cupania paniculata Cambess.	ARO			X		
*Cupania racemosa (*Vell.) Radlk.	ARO	X	X	X	X	X
Cupania revoluta Radlk.	ARO			X	X	
Cupania sp.	ARO					X
Paullinia pinnata L.	TRE			X		X
Paullinia trigona Vell.	TRE		X		X	
Serjania salzmanniana Seem.	TRE			X		X
Talisia esculenta (A. St.-Hil) Radlk.	ARO	X		X	X	
Talisia sp.	ARO					X
Sapindaceae	TRE		X	X		
Sapotaceae						
Pouteria grandiflora (A.DC.) Baehni	ARO					X
Pouteria peduncularis (Mart. & Eichlerex Miq.) Baehni	ARO					X
Pouteria sp.	ARO					X
Sapotaceae	ARO			X		
Simaroubaceae						
Simarouba amara Aubl. ♦	ARO		X	X		X
Solanaceae						
*Solanumas perum*Rich.	ARB			X		
Solanum paludosum Moric.	ARB	X			X	X
Solanum sp.	ARB	X				

Verbenaceae

Aegiphila pernambucensis Moldenke*.*	ARB			X	
Aegiphila vitelliniflora Walpers.	ARB			X	
Aegiphila sp.	ARB	X			
Lantana radula Sw.	ARB	X			X
Violaceae					
Amphirrhox longifolia (A.St.-Hil.) Spreng.	ARO			X	
Paypayrola blanchetiana Tul.	ARO		X		X
Unknown 1	ERV		X		
Unknown 2	ERV		X		

140
141 Significant differences were observed in terms of number of species in tree and herbaceous
142 habits among the different ages studied (Fig. 1). There was a trend of increasing tree
143 species and decreasing of herbs along the chronosequence, where mature forest had the
144 highest number of species (p < .02) in relation to the young (5 years). In the
145 chronosequence, another trend was observed, in which the richness of the herbaceous
146 growth form decreased towards the mature forest, where the forest of the initial stage (5
147 years) presented the highest proportion, differing from the other forests studied (p < .01)
148 (Fig. 1). In this way, it was observed that from 16 years after the abandonment the
149 proportion of the growth forms were closer to the mature forest.

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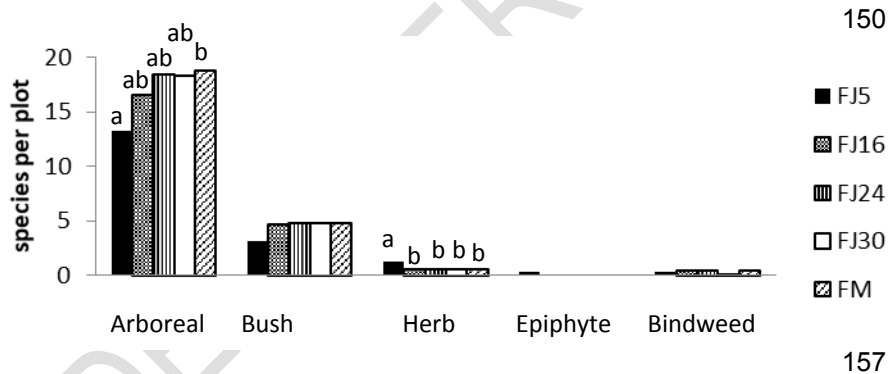
158
159 **Fig. 1. Average number of species per plot with different growth habits in four young**
160 **forests (5, 16, 24 and 30) and a mature forest.** *Letters indicate that the average within each*
161 *habit do not differ by Tukey test (P <0.05) and the same letter are not statistically different from each*
162 *other. Young forests (FJ5 = 5 years = 16 years FJ16, FJ24 = 24, FJ30 = 30 years) and mature forest*
163 *(FM).*
164

165 However, the analysis of TWINSPAN (Table 1) identified in division 1 (eigenvalue 0.911) the
166 mature forest area of the young forests. *Albizia polycephala, Artocarpus heterophyllus,*
167 *Xylopia frutescens, Apeiba tibourbou* and *Vismia guianensis* were arboreal species
168 indicative of young forests, as well as the *Acrocomia sclerocarpa* palm, which was also
169 common in young forests. In the mature forest, only species with more advanced stages
170 were found, such as *Pogonophora schomburgkiana*, *Simarouba amara*, *Guatteria*
171 *schomburgkiana, Maytenus distichophyla, Dialium guianense* and *Lecythis pisonis* (Table 1).
172 The species considered as indicators of mature forest are in agreement with several authors

173 [28,29], since they are species with similar habitat characteristics, being common in the inner
174 of forests and shaded areas.

175 NMDS analysis applied to the tree species in the chronosequence revealed the formation of
176 two groups, isolating the mature forest (FM) (Fig. 2A). The grouping analysis individualized
177 the mature forest (FM) and two groups, one formed by the young forests of 5 (FJ 5) and 16
178 years (FJ 16) of regeneration, with 46% similarity and a second formed by the young forests
179 of 24 (FJ 24) and 30 years (FJ 30), with 50% similarity (Fig. 2B). The two groups composed
180 of young forests (FJ 5 - FJ 16 and FJ 24 - FJ 30) differed from mature forest in floristic
181 composition with 28% similarity. This same pattern was also evident in the principal
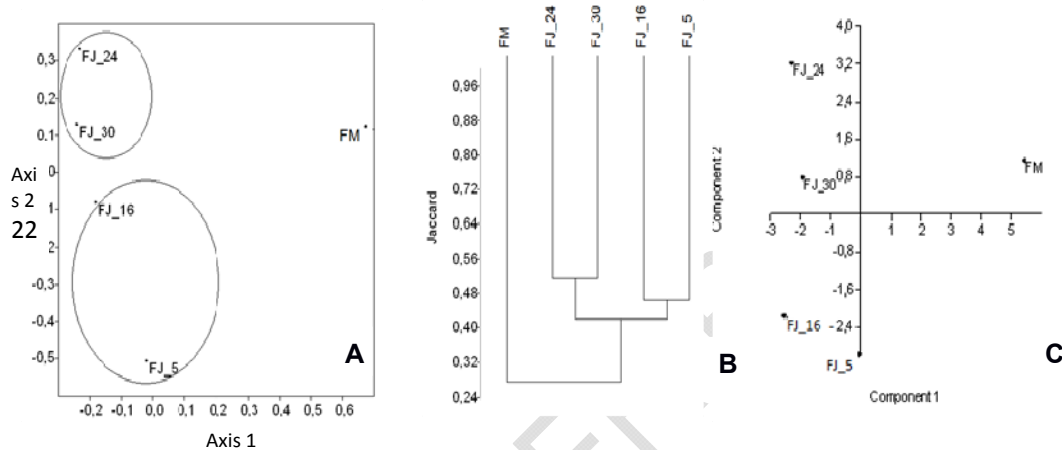
182 component analyzes (PCA) (Fig. 2C).

183
184 **Fig. 2. Multivariate analysis based on the presence and absence of tree species**
185 **sampled in young and mature forest forests. Ordination by the not metric**
186 **multidimensional scaling method (NMDS) (A), cluster analysis generated by the**
187 **Jaccard similarity indices and average link method group (B) and principal**
188 **component analysis (C). Young forests (FJ_5 = 5 years FJ_16 = 16, FJ_24 = 24, FJ_30**
189 **= 30 years) and mature forest (FM).**
190

191 The results of all multivariate analyzes indicate the formation of two groups of young forests
192 (5 and 16 years old and another 24 and 30 years old), individualizing the mature forests. The
193 literature also points out that the recovery of floristic young forests occurs slowly [31,2].
194 Regarding this slowness, the fact that young forests and mature forest share 43 tree
195 species, 15 in all forests, suggests that the floristic composition of young forests tends to
196 converge with mature forest, as well as recorded in several researches in tropical forests
197 [2,32,33,34,30].

198 It can be hypothesized that the floristic convergence and the strong influence of the initial
199 floristic composition on the chronosequence flora in the fragments may be related to the fact
200 that this area presents more than 24% vegetation cover, since, according to [12], landscapes
201 above the threshold of 10-30% of covering tend to have positive effects on the persistence of
202 species, leading to different trajectories according to the size and connectivity of the
203 patches.
204

4. CONCLUSIONS

In the chronosequence studied at the São José Plant, it can be seen that from 16 years, young forests tended to converge with mature forest in proportion of tree and herbaceous species. The distribution of 43 tree species among young and mature forests suggests that the floristic composition of young forests tends to resemble that of mature forest, confirming the hypotheses of floristic convergence.

Floristic convergence may have been influenced by the São José Plant landscape, which has a 24% vegetation cover, facilitating the persistence of the species in the studied fragments. In addition to sharing 43 species, there were 15 species that were present at all ages, supporting the hypothesis of initial floristic composition, in which the species that participate in the succession over time are established from the beginning in the abandoned area.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Denich M. Estudo da importância de uma vegetação secundária nova para o incremento da produtividade do sistema de produção na Amazônia Oriental Brasileira. Belém: Embrapa - CPATU/ GTZ; 1991.

2. Chazdon RL, Peres CA, Dent D, Sheil D, Lugo AE, Lamb D et al. The potential for species conservation in tropical secondary forests. Conservation Biology. 2009;23(6): 1406-1417. Doi: https://doi.org/10.1111/j.1523-1739.2009.01338.x

3. Chazdon, RL. Regeneração de florestas tropicais. Boletim do Museu Paraense Emílio Goeldi. Ciências Naturais. 2012;7(3): 195-218.

4. Clements FE. Plant succession: analysis of the development of vegetation. Washington, D.C.: Carnegie Institute of Washington Publication; 1916.

5. Gleason HA. The individualistic concept of the plant association. Bulletin of the Torrey Botanical Club. 1926;53(1): 7-26.

6. Egler FE. Vegetation science concepts I. Initial floristic composition, a factor in old-field vegetation development. Plant Ecology. 1954;4(10): 412-417.

7. Pickett STA, Collins SL, Armeto JJ. A hierarchical consideration of causes and mechanisms of succession. Vegetatio. 1987;69(1): 109-114.

8. Piotto D, Montagnini F, Thomas W, Ashton M, Oliver C. Forest recovery after swidden cultivation across a 40-year chronosequence in the Atlantic forest of southern Bahia, Brazil. Plant Ecology. 2009;205(2): 261-272. Doi: doi: 10.1007/s11258-009-9615-2.

9. Toledo M, Poorter L, Pena-Claros M, Alarcon A, Balcazar J, Chuvina J et al. Patterns and determinants of floristic variation across lowland forests of Bolivia. Biotropica. 2011;43(4): 405-413. Doi: 10.1111/j.1744-7429.2010.00711.x.

257   10. Harvey BJ, Holzman BA. Divergent successional pathways of stand development
258   following fire in a California closed-cone pine forest. Journal of Vegetation Science. 2014;25
259   (1): 88-99. Doi: https://doi.org/10.1111/jvs.12073.

261   11. Del Moral R, Saura JM, Emenegger JN. Primary succession trajectories on a barren
262   plain, Mount St. Helens, Washington. Journal of Vegetation Science. 2010;21(5): 857-867.
263   Doi: https://doi.org/10.1111/j.1654-1103.2010.01189.x.

265   12. Andrén H. Effects of habitat fragmentation on birds and mammals in landscapes with
266   different proportions of suitable habitat: a review. Oikos. 1994

268   13. IBGE – (Instituto Brasileiro de Geografia e Estatística). Manual técnico da vegetação
269   brasileira. Manuais técnicos em Geociências, 1. Rio de Janeiro: IBGE; 2012.

271   14. Trindade MB, Lins-e-Silva ACB, Silva HP, Filgueira, SB, Schessl M. Fragmentation of
272   the Atlantic Rainforest in the northern coastal region of Pernambuco, Brazil: recent changes
273   and implications for conservation. Bioremediation, Biodiversity and Bioavailability. 2008;2(1):
274   5-13.

276   15. Silva MAM. Efeito de borda na estrutura e na dinâmica espaço-temporal de um
277   fragmento de Mata Atlântica no nordeste do Brasil. Recife: Universidade Federal Rural de
278   Pernambuco; 2010.

280   16. Filgueiras TS, Brochado AL, Nogueira PE, Guala II GF. Caminhamento: um método
281   expedito para levantamentos florísticos qualitativos. Cadernos de Geociências. 1994;12(1):
282   39-43.

284   17. Mori AS, Silva LAM, Lisboa G, Coradin L. Manual de manejo do herbário fanerogâmico.
285   Ilhéus: Centro de Pesquisas do Cacau; 1989.

287   18. APG III. An update of the Angiosperm Phylogeny Group classification for the orders and
288   families of flowering plants: APG III. Botanical Journal of the Linnean Society. 2009;161(2):
289   105-121. Doi: https://doi.org/10.1111/j.1095-8339.2009.00996.x.

291   19. Hammer Ø, Harper DAT, Ryan PD. PAST: Paleontological statistics software package
292   for   education   and   data   analysis.   Paleont   Electronica   4:   9p.
293   http://www.paleoelectronica.org/2001_1/past/ issue1_01.htm.

295   20. Brower JE, Zar JH. Field and laboratory methods for general ecology.2ªed. Iowa, W.C.
296   Brown Company Publishes; 1984.

298   21. Jongman RHG, Ter Braak CJF, Van Tongeren OFR. editors. Data analysis in community
299   and landscape ecology, 2nd Edition. New York: Cambridge University Press. 1995; 71(3):
300   355-366.

302   22. Clarke KR, Warwick RM. Change in marine communities: an approach to statistical
303   analysis and interpretation. Plymouth: Plymouth Marine Laboratory; 1994.

305   23. Valentim JA. Ecologia numérica: uma introdução a análise multivariada de dados
306   ecológicos. Rio de Janeiro: Interciência; 2000.

308   24. Mccune B, Mefford MJ. PC-ORD version 4.0: Multivariate analysis of ecological data –
309   users guide. MjM Software Design. Glaneden Beach; 1999.

310

311   25. Gómez-Pompa A, Vázquez-Yanes C. Successional studies of a rain forest in México. In:
312   West DC, Shugart HH, Botkin DB. (Eds.), Forest succession: concepts and application. New
313   York: Springer-Verlag; 1981.
314
315   26. Finegan B. Pattern and process in Neotropical secondary rain forests: the first 100 years
316   of sucession. Trends in Ecology and Evolution. 1996;11(3): 119-124.
317
318   27. Spyreas G, Meiners SJ, Matthews JW, Molano-Flores B. Succession al trends in floristic
319   quality. Journal of Applied Ecology. 2012;49(2): 339-348. Doi: doi: 10.1111/j.1365-
320   2664.2011.02100.x.
321
322   28. Alves Júnior FT, Brandão CFL, Rocha KD, Marangon LC, Ferreira RLC. Efeito de borda
323   na estrutura de espécies arbóreas em um fragmento de Floresta Ombrófila Densa, Recife,
324   PE. Revista Brasileira de Ciências Agrárias. 2006;1(1): 49-56.
325
326   29. Gomes JS, Lins-e-Silva ACB, Rodal MJN, Silva HCH. Estrutura do sub-bosque lenhoso
327   em ambientes de borda e interior de dois fragmentos de floresta atlântica em Igarassu,
328   Pernambuco, Brasil. Rodriguésia. 2009;60(2): 295-310.
329
330   30. Nascimento LM, Sampaio EVSB, Rodal MJN, Lins-e-Silva ACB. Natural forest
331   regeneration in abandoned sugarcane fields in northeastern Brazil: floristic changes. Biota
332   Neotropica. 2012;(12): 1-14. Doi: http://dx.doi.org/10.1590/S1676-06032012000400009.
333
334   31. Guariguata MR, Ostertag R. Neotropical secondary forest succession: changes in
335   structural and functional characteristics. Forest Ecology and Management. 2001;148(9):
336   185-206.
337
338   32. Letcher SG, Chazdon RL. Rapid recovery of biomass, species richness, and species
339   composition in a forest chronosequence in Northeastern Costa Rica. Biotropica. 2009;41(5):
340   608-617. Doi: https://doi.org/10.1111/j.1744-7429.2009.00517.x.
341
342   33. Norden N, Chazdon RL, Chao A, Jiang YH, Vi´Lchez-Alvarado B. Resilience of tropical
343   rain forests: tree community reassembly in secondary forests. Ecology Letters. 2009;12(4):
344   385-394. Doi: https://doi.org/10.1111/j.1461-0248.2009.01292.x.
345
346   34. Nascimento LM, Sampaio EVSB, Rodal MJN, Lins-e-Silva ACB. Secondary succession
347   in a fragmented Atlantic Forest landscape: evidence of structural and diversity convergence
348   along a chronosequence. Journal of Forest Research. 2014;19(6):1-13. Doi:
349   https://doi.org/10.1007/s10310-014-0441-6.
350
351
352
353
354
355